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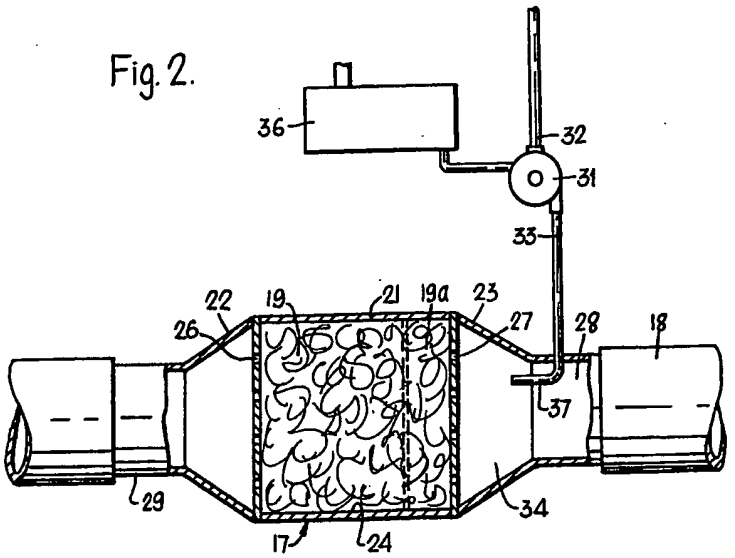
(54) **Rejuvenation of an exhaust gas particulate filter**

(57) Combustible particulate matter is separated from a diesel exhaust gas stream in a filter bed 19 having an oxidation catalyst either on the bed material or in a pre-filter bed 19a disposed upstream of said bed 19.

A control means 36 actuates injection metering apparatus 31 at spaced time intervals, e.g. at predetermined intervals or at predetermined temperatures of the exhaust gas, to inject an amount of combustible fluid into said pre-filter bed 19a to burn away the accumulated matter from both beds. This fuel may be diesel fuel or propane.

Fig. 2.



The drawing originally filed was informal and the print here reproduced is taken from a later filed formal copy.

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Fig. 1.

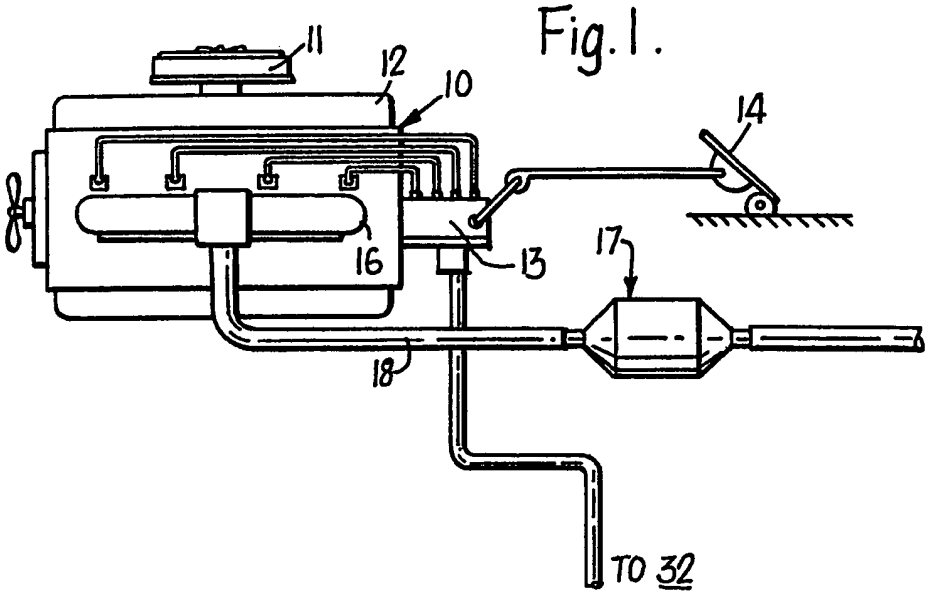
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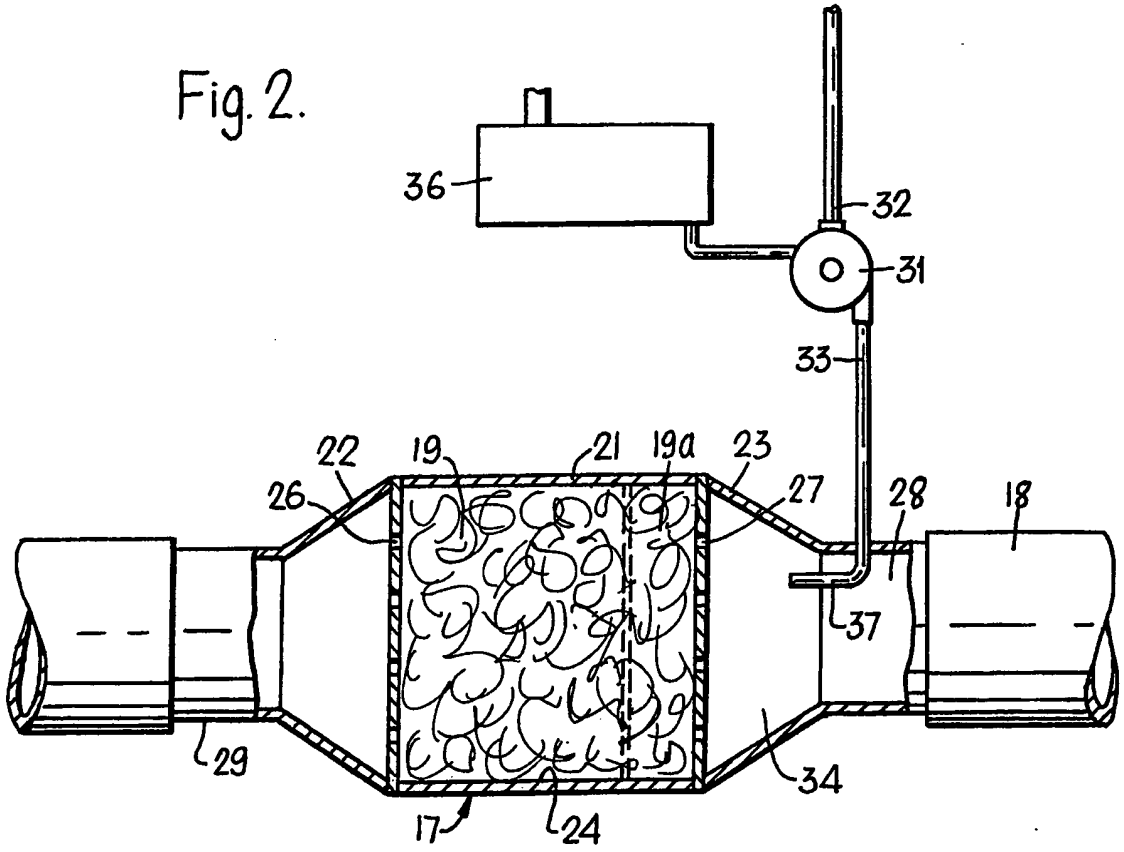
Fig. 2.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SPECIFICATION

Method for cyclic rejuvenation of an exhaust gas particulate filter, and apparatus

With any internal combustion engine it is desirable to treat the exhaust gases so that they can be safely discharged into the atmosphere. In some engines, particularly of the diesel type, among the most prevalent operating problems is the presence of particulates which are carried in the exhaust gas stream.

Primarily, the particulates are normally bits of carbon. They result from the incomplete combustion of the hydrocarbon fuel under certain engine operating conditions. However, the operating efficiency of the engine is also a contributing factor to the amount of carbon produced.

The presence of relatively large amounts of carbon particles in any exhaust gas stream may be evidenced by a dark, smoky, undesirable effluent. Such smoke is not only offensive aesthetically; in large quantities it can be unhealthy.

Means have been provided and are known to the prior art, for the elimination or minimization of the particulate content in exhaust discharge streams. However, it has been found that while the particulates can be eliminated by a suitable filter of proper construction, eventually the latter can become saturated and/or inoperable due to excessive particulate accumulations.

It is further known that the overall engine exhaust gas treating process can be expedited. This is achieved not only by passing the hot gas stream through a filter medium, but by providing the filter with a catalyst which will promote combustion of the retained particles.

It should be appreciated that the generation of carbon particles is prevalent under all diesel engine operating conditions. It is further appreciated that the quantity and quality of an exhaust gas stream created in any internal combustion engine will vary in accordance with the operating characteristics of the engine.

For example, the temperature range experienced by the diesel exhaust gas stream can vary between slightly above ambient air temperature, and temperatures in excess of 650°C. When the exhaust gas is hot enough, the carbon particles trapped in a filter will be combusted. However, the engine operating condition where this rejuvenation can occur is seldom reached in diesel passenger cars.

Where it is found that an engine continuously operates under such circumstances that the particulates are continuously produced and accumulated in the filter, the particulate trapping filter bed must be occasionally rejuvenated.

Under usual circumstances, rejuvenation will consist of merely introducing the hot exhaust gas stream, containing sufficient oxygen, into the filter bed to contact and ignite or incinerate the retained carbon particles. The combustion of any large and contained carbon accumulation can, however, produce temperatures greatly in excess of that of the exhaust gas. The result is that at such excessive temperatures, the filter bed or element is susceptible to thermal shock, damage or distortion.

Toward achieving a satisfactory or limited rate of carbon removal from an exhaust gas system without incurring resulting damage to the filter, the unit presently disclosed is provided. The instant system thus comprises in brief, the reaction chamber or section which contains a catalyst bed through which at least a portion of the exhaust gas stream is passed. This catalyst segment can be incorporated within the particulate trapping bed, or it can precede it.

To assure that the main or primary filter bed or beds always remain functional, the exhaust gas stream is periodically and regularly heated to a temperature in excess of the temperature required to initiate combustion of retained particles.

Physically, the heating step is achieved by adding a desired amount of a flammable fluid directly into the exhaust gas stream. This fuel mixes with the diesel exhaust, which has excess oxygen. When the mixture contacts the catalyst, an exotherm will occur and raise the temperature of the exhaust gas stream at least to the combustion temperature of the carbon particles which are retained in the main filter bed.

The main filter bed will thus be regularly and at periodic intervals rejuvenated. Such treatment, if repeated at predetermined inervals will preclude any carbon accumulation which might otherwise lead to thermal stress or damage to the bed at such time as the accumulation is combusted.

It is therefore an object of the invention to provide a filter of the type disclosed which is capable of containing combustible particulates from an exhaust gas stream, and subsequently being periodically rejuvenated by burning said particulates.

A further object is to provide a paticulate filter of the type disclosed which is capable of removing solid elements from an exhaust gas stream while permitting periodic rejuvenation of the filter element. The rejuvenation can be accomplished while the engine is operating at conditions that would normally not result in exhaust gas temperatures sufficient to accomplish the task.

A still further object is to provide an exhaust gas treating unit which is capable of removing particulates from an exhaust gas stream without jeopardizing the integrity of the filter bed by subjecting the latter to thermal shock or damage.

Figure 1 illustrates a diesel engine of the type contemplated with which the present filter cooperates.

Figure 2 is an enlarged view in cross-section, of the filter element shown of Figure 1.

To facilitate the present description, the internal combustion engine 10 or source of exhaust gas, will be considered to be of the diesel type. In the latter, air is sequentially introduced to the various combustion chambers, from an air filter 11, by way of manifold 12. Fuel is therefore injected into each combustion chamber from a fuel pump 13 by way of an engine control linkage 14.

The hot exhaust gas stream is carried from exhaust manifold 16 and conducted through an exhaust pipe 18 to a smoke filter 17. Although a

sound absorbing muffler could be inserted into the exhaust pipe, such an element is not essential to the instant system.

The exhaust gas stream subsequent to leaving exhaust manifold 16, will be at a temperature within the range of about 90° to 650°C. The precise temperature will depend on the operating conditions of the engine. For example, at low and idle speeds, the exhaust gas will be relatively cool or only slightly heated. Consequently, as the exhaust gas stream enters filter 17, the particulates carried in the stream will be retained along the many diverse passages within the filter bed 19.

While the exhaust gas is comprised primarily of a combination of gases, it normally embodies sufficient oxygen content to support at least a limited degree of combustion within the stream itself.

Filter 17 comprises in essence an elongated metallic casing 21 having opposed end walls 22 and 23 which define an internal reaction chamber 24 therebetween. The latter chamber is occupied to a large extent by at least one bed 19 formed of material particularly adapted to provide a plurality of irregular passages.

The functon of this bed, or similar beds which supplement it, is to define a series of passages along which the gas will pass. During such passage, the particulate matter carried on the stream will be retained along the various passage walls.

In one embodiment, bed 19 can be formed of a metallic mesh-like mass such as steel wool or the like which is shaped to substantially fill the filter reaction chamber.

Bed 19 can be optionally supported at its upstream and downstream ends by perforate panels 26 and 27 or other similar transverse members. The latter are carried on the casing 21 wall to support the one or more beds therein.

The filter upstream wall 23 is provided with inlet port 28 for introducing gas to the upstream side of the bed 19. In a similar manner the downstream panel 26 is communicated with an outlet port 29 to carry away gases which leave the bed.

To best achieve the filtering action on the exhaust gas stream, filter bed 19 can be comprised as noted of a suitable medium which is capable of retaining the solid particles from the stream. However, to facilitate subsequent combustion of the retained particles, the filter medium can be provided on its surface with a suitable catalyst of the type which will promote oxidation of fuel and the combustible particles.

When filter bed 19 is utilized without the benefit of a catalyst, in accordance with the present invention, the forward or upstream and thereof is provided with a pretreating segment 19a. The latter includes a catalyst material which will be capable of producing the desired oxidation of fuel and the particles. This pre-filtering chamber 19a can be physically a part of the filter bed 19, or it can be a discrete segment thereof.

The pre-filter segment 19a can for example be positioned in the forward portion of the casing 21 whereby to contact incoming exhaust gas as soon as the latter enters the filter casing.

Toward achieving the present preheating of the exhaust gas stream, an injection system is provided which embodies primarily a source of a combusible fuel together with means for inserting a measured amount of said fuel into the heated exhaust gas stream. Said fuel source can be either in liquid or gaseous form to achieve the desired preheating function.

The supplementary fuel source can, as presently shown, as diesel fuel utilized for powering internal combustion engine 10. Alternatively it can be a compressed gas such as propane or the like which is carried for the express purpose of injection into the pre-filtering chamber. In brief, the supplementary fuel can be any of a number of known volatile substances, hydrocarbon or otherwise, which are capable of reacting in the catalyst chamber.

The injection system thus is provided with a pump 31, or other suitable metering means, having the inlet side 32 thereof connected to the fuel pump 13. The pump 13 in turn is communicated with an injector 33 which can be provided with one or more nozzles 37 disposed at the forward end of the catalyst-containing pre-filtering chamber 34.

As pump 31 is periodically actuated by the injector control means 36, a measured amount of the combustible fluidized fuel will be passed directly into the pre-filtering chamber 34 wherein it will be ignited by contact with the heated exhaust gas in the presence of the oxidizing catalyst.

To achieve the periodic exhaust gas heating step, pump 31 control system 36 is designed particularly to actuate the pump at regular preset periods of time. These intervals can be determined on the basis of the mileage the engine has logged or on the actual time the engine has run. Further actuation can be a function of the temperature within the filter element. In any instance, the purpose of the injection timing is such that the carbon will be periodically incinerated from the filter regardless of engine operating conditions. The spacing of the intervals is such as to avoid any excess accumulation of carbon even under the worst engine operating conditions.

Other modifications and variations of the invention as hereinbefore set forth can be made without departing from the spirit and scope thereof, and therefore, only such limitations should be imposed as are indicated in the appended claims.

CLAIMS

1. Apparatus for treating a hot exhaust gas stream carrying combustible particulate matter, comprising at least one filter element 17 having a reaction chamber 24 with an inlet port 28 communicating with a source 18 of exhaust gas, and a main filter bed 19 positioned in said reaction chamber 24, which comprises

a pre-filter bed 19a disposed upstream of said main bed 19, and containing a catalytic filtering medium,

an injection metering apparatus 31 having an inlet 32 communicating with a source of a combustible fluid, and having a discharge port 33 communicating with said pre-filter bed 19a, and

injection control means 36 controllably connected to said injection metering apparatus 31 and operable to actuate the latter at spaced time intervals to inject an amount of combustible fluid into said pre-filter bed 19a.

2. Apparatus as claimed in Claim 1, wherein the pre-filtering bed is integral with the main filter bed.

3. Apparatus as claimed in Claim 1, wherein the pre-filter bed is contiguous with the main filter bed.

4. Apparatus as claimed in any of Claims 1 to 3 wherein the metering means inlet communicates with a source of liquid fuel.

5. Apparatus as claimed in any of Claims 1 to 3 wherein the metering means communicates with a source of a pressurized gas.

6. Apparatus as claimed in any of Claims 1 to 5 wherein the injection control means includes a timer operable to actuate the injection metering means at predetermined time intervals.

7. Apparatus as claimed in any of Claims 1 to 5 wherein the injection control means is operable to actuate the injection metering means at predetermined exhaust gas stream temperatures.

8. A method for removing combustible particulate matter from a stream of exhaust gas which comprises,

passing said exhaust gas stream into a filter bed to retain at least a portion of said particulate matter within the bed,

periodically heating at least a portion of said exhaust gas prior to its entering said bed, to a temperature in excess of the ignition temperature of said retained combustible particulates,

and passing said heated exhaust gas into contact with said particulate-retaining filter to combust said retained particulates.

9. A method as claimed in Claim 8, wherein the gas is heated by injecting a combustible fuel into the exhaust gas stream before it enters the filter bed.

10. A method as claimed in Claim 9, wherein the combustible fuel is a liquid fuel.

11. A method as claimed in Claim 10, wherein the liquid fuel is diesel fuel.

12. A method as claimed in Claim 9, wherein the combustible fuel is a gaseous fuel.

13. A method as claimed in Claim 12, wherein the gaseous fuel is propane.

14. Apparatus as claimed in Claim 1 and substantially as hereinbefore described with reference to Figure 2 of the accompanying Drawings.

15. A method as claimed in Claim 9 and substantially as hereinbefore described with reference to Figure 2 of the accompanying Drawings.

New claims or amendments to claims filed on 25 Feb. 1981
Superseded claims 1
New or amended claims:-

1. Apparatus for treating a hot exhaust gas stream carrying combustible particulate matter, comprising at least one filter element 17 having a reaction chamber 24 with an inlet port 28 communicating with a source 18 of exhaust gas, and a main filter bed 19 positioned in said reaction chamber 24, which comprises

a pre-filter bed 19a disposed upstream of said main bed 19, and containing a catalytic medium,

an injection metering apparatus 31 having an inlet 32 communicating with a source of a combustible fluid, and having a discharge port 33 communicating with said pre-filter bed 19a, and

injection control means 36 controllably connected to said injection metering apparatus 31 and operable to actuate the latter at spaced time intervals to inject an amount of combustible fluid into said pre-filter bed 19a.

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